International Journal of Reproduction, Contraception, Obstetrics and Gynecology
Rao N et al. Int J Reprod Contracept Obstet Gynecol. 2025 Sep;14(9):3060-3064
www.ijrcog.org
pISSN 2320-1770 | eISSN 2320-1789

DOI: https://dx.doi.org/10.18203/2320-1770.ijrcog20252741

Original Research Article

Predictive value of cerebroplacental ratio measured by Doppler ultrasound for neonatal outcomes in hypertensive disorders of pregnancy: a prospective observational study

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Received: 14 July 2025
Revised: 12 August 2025
Accepted: 14 August 2025

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ABSTRACT

Background: Hypertensive disorders of pregnancy (HDP) are among the most significant contributors to maternal and perinatal morbidity and mortality. Inadequate placental perfusion and foetal hypoxia are key mechanisms affecting fetal growth. The cerebroplacental ratio (CPR), derived from Doppler ultrasound of the middle cerebral artery (MCA) and umbilical artery (UA), is a non-invasive method to assess foetal well-being. This study evaluated the CPR as a predictive tool for adverse neonatal outcomes in HDP.
Methods: A prospective observational study was conducted at Saraswathi Institute of Medical Sciences, including 160 singleton pregnancies complicated by HDP beyond 32 weeks of gestation. All participants underwent Doppler velocimetry to assess CPR and were divided into group A (CPR≥1.0) and group B (CPR<1.0). Outcomes assessed included birth weight, Apgar score, NICU admission, and mode of delivery. Statistical analysis involved chi-square tests and sensitivity/specificity calculations.
Results: CPR<1.0 was significantly associated with higher caesarean section rates (80% versus 40%), low birth weight (<2500 gm in 67.5% versus 28.8%), low Apgar scores (<7 in 68.8% versus 25%), and increased NICU admissions (72.5% versus 28.8%). CPR showed high specificity but moderate sensitivity for predicting poor outcomes.
Conclusions: CPR is a valuable Doppler parameter that can aid in identifying foetuses at risk in hypertensive pregnancies, enabling timely intervention to improve perinatal outcomes.

Keywords: Cerebroplacental ratio, Doppler ultrasound, Fetal compromise, Hypertensive disorders of pregnancy, Low birth weight, NICU admission

INTRODUCTION

Hypertensive disorders of pregnancy (HDP) are among the most common complications in obstetrics, affecting 5-10% of all pregnancies globally. These include gestational hypertension, preeclampsia, and eclampsia, which together contribute significantly to maternal morbidity and adverse foetal outcomes.[1] The pathophysiology of HDP involves defective trophoblastic invasion and abnormal remodelling of spiral arteries, leading to placental hypoperfusion, increased vascular resistance, and intrauterine growth restriction (IUGR).[1-4]

Inadequate placental function and foetal hypoxia are known to trigger adaptive circulatory changes in the fetus, known as the "brain-sparing effect".[2,3] This phenomenon is characterized by redistribution of foetal blood flow-preferentially toward the brain at the expense of other organs- detectable by Doppler ultrasound. Specifically, a decrease in the pulsatility index (PI) of the middle cerebral artery (MCA) and an increase in the umbilical artery (UA) PI are used to calculate the cerebroplacental ratio (CPR).[2,3,5] A low CPR (<1.0) reflects this compensatory mechanism and has been associated with adverse perinatal outcomes.

The CPR is increasingly being recognized as a superior marker of foetal compromise compared to individual Doppler indices.[6-8] Meta-analyses and large studies have found CPR to be more sensitive in detecting foetuses at risk of hypoxia, especially in high-risk pregnancies including those complicated by hypertension and foetal growth restriction.[7,10-15] The 2015 TRUFFLE study further established CPR as a reliable tool to determine timing of delivery in early-onset growth restriction.[10]

Despite growing international evidence, the utility of CPR in HDP is not well established in Indian clinical settings. There is a paucity of prospective studies evaluating its correlation with perinatal outcomes like birth weight, Apgar score, NICU admission, and caesarean section rates in the Indian population.

Thus, this study aimed to assess the predictive value of CPR in hypertensive pregnancies and evaluate its correlation with key neonatal outcomes beyond 32 weeks of gestation.

METHODS

Study design and setting

This was a prospective observational study conducted in the department of obstetrics and gynecology at Saraswathi Institute of Medical Sciences, Hapur UP over a 24-month period (March 2023 to February 2025). Ethical approval was obtained from the institutional ethical committee prior to study commencement, and written informed consent was secured from all participants.

Study population

A total of 160 pregnant women presenting with hypertensive disorders beyond 32 weeks of gestation were included in the study. Hypertensive disorders considered for inclusion were gestational hypertension, preeclampsia, and eclampsia, defined as per ACOG guidelines.[16]

Inclusion criteria

Singleton pregnancy, age 21-35 years, gestational age >32 weeks confirmed by early ultrasound, diagnosed with hypertensive disorders of pregnancy (HDP).

Exclusion criteria

Multifetal gestation, congenital fetal anomalies, Rh isoimmunisation, pre-existing medical disorders (diabetes mellitus, renal or cardiovascular diseases), incomplete antenatal records.

Doppler assessment and CPR calculation

All participants underwent obstetric ultrasound and Doppler velocimetry performed by experienced radiologists using standard equipment. The umbilical artery (UA) and middle cerebral artery (MCA) pulsatility indices (PI) were recorded. The cerebroplacental ratio (CPR) was calculated as:

CPR=MCA PI UA PI CPR = \frac (MCA\, PI) (UA\, PI) CPR=UAPI MCAPI

Measurements were performed in the absence of foetal breathing or movement, during foetal quiescence, as recommended by international guidelines.[7,9]

Participants were divided into group A: CPR≥1.0 and group B: CPR<1.0.

Outcome measures

Maternal and neonatal data were recorded on a structured proforma. Key outcomes included: Mode of delivery (vaginal or caesarean section). Birth weight (normal: ≥2500 gm, low birth weight: <2500 gm). Apgar score at 5 minutes (<7 considered abnormal). NICU admission (yes/no). Perinatal mortality (stillbirth or neonatal death).

Statistical analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 20. Categorical variables were expressed as percentages and compared using the chi-square test. Diagnostic accuracy was assessed using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) calculations. A p value <0.05 was considered statistically significant.

RESULTS

A total of 160 women were studied, 80 in each group.

Table 1: Maternal age distribution in CPR groups.

Age group (years)	Group A (CPR≥1.0)	Group B (CPR<1.0)	Total
21-25	35 (43.8%)	34 (42.5%)	69
26-30	33 (41.2%)	30 (37.5%)	63
31-35	12 (15.0%)	16 (20.0%)	28
Total	80 (100%)	80 (100%)	160

Most participants were between 21-30 years. Age distribution was similar across both groups. In group A, the mean age was 24.30±3.90 years, and in group B, it was 24.74±4.07 years. The mean age was comparable amongst both the groups.

Table 2: Gestational age at delivery.

Gestational age	Group A	Group B	Total
33-34 weeks	18	22	40
35-36 weeks	38	42	80
>37 weeks	24	16	40
Total	80	80	160

The distribution of gestational age was comparable in both groups. In group A mean gestational age was 36.20±1.10 and in group B, it was 36.35±1.05.

Table 3: Mode of delivery by CPR group.

Mode of delivery	Group A	Group B
Vaginal	48	16
Caesarean section	32	64

Majority of females in group A had a vaginal delivery (60%) while in those in group B, the majority had lower section cesarean delivery (80%). It was statistically significant with p value of 0.0149.

Table 4: Birth weight comparison.

Birth weight (gm)	Group A	Group B	Total
≥2500 (normal)	57	26	83
<2500 (LBW)	23	54	77
Total	80	80	160

71.25% in group A had babies with >2500 birth weight while 67.50% in group B had babies with <2500 birth weight. It can be seen that babies with low birth weight had much more abnormal CPR values than babies weighing >2.5 kg. It is statistically significant with p value <0.001.

Table 5: Apgar score at 5 minutes.

Apgar score	Group A	Group B	Total
≥7	60	25	85
<7	20	55	75
Total	80	80	160

In group A, 20 babies had a <7 APGAR score at 5 minutes (25%) while 55 babies in group B (68.75%) had an APGAR score <7 at 5 minutes. It was statistically significant with p value of <0.001.

Table 6: NICU admission.

NICU admission	Group A	Group B	Total
Required	23	58	81
Not required	57	22	79
Total	80	80	160

In group A, twenty-three babies had NICU admission (28.75%) while fifty-eight babies in group B had NICU admission (79.50%). It was statistically significant with p values <0.001.

Table 7: Diagnostic performance of CPR.

Outcome	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Low birth weight	49	82	70	65
Apgar <7	47	63	58	55
NICU admission	43	73	62	58

CPR had high specificity in detecting adverse outcomes.

DISCUSSION

This study highlighted the strong predictive role of the cerebroplacental ratio (CPR) in identifying adverse neonatal outcomes in hypertensive pregnancies. Our findings demonstrate that a CPR value <1.0 was significantly associated with increased caesarean section rates, low birth weight, poor Apgar scores, and higher NICU admission rates.

The pathophysiological basis of CPR lies in foetal adaptation to hypoxia. In compromised foetuses, there is vasodilation of the middle cerebral artery (reduced MCA PI) and increased resistance in the umbilical artery (elevated UA PI), resulting in a decreased CPR- a marker of "brain-sparing" effect.[2,3,17] This compensatory mechanism reflects early signs of foetal compromise even before cardiotocographic or biophysical profile abnormalities appear.[6]

Our results are consistent with those of Patil et al, who reported significantly lower birth weights and Apgar scores among fetus with CPR<1.[12] Similarly, Sukphadung et al found that low CPR in hypertensive pregnancies was associated with increased neonatal morbidity and NICU admission.[2] Saxena also emphasized CPR's utility as a non-invasive, reliable predictor of foetal compromise.[13]

Internationally, the TRUFFLE study supported the use of CPR in timing delivery in early-onset fetal growth restriction.[10] Khalil et al further demonstrated that abnormal CPR in the third trimester was associated with perinatal morbidity and mortality, especially in high-risk pregnancies.[6]

Our study observed that CPR had a high specificity (up to 82%), indicating that when CPR is normal, the likelihood of adverse outcome is low. However, the moderate sensitivity (~45-49%) suggests that CPR alone may not detect all at-risk fetus- hence, it should be used in conjunction with other clinical parameters.[8,14]

Unterscheider et al also noted that CPR, when combined with growth scans and biophysical scores, improves decision-making for preterm delivery.[14] Additionally, Baschat and Odibo et al suggested that CPR may help reduce perinatal mortality by identifying the optimal time for delivery in growth-restricted or hypertensive pregnancies.[3,11]

Although useful, CPR assessment is operator-dependent and may vary based on technical skill. Our study was limited by its single-center design and relatively small sample size, which may limit generalizability. Also, long-term neonatal follow-up was not included. However, the prospective nature, strict inclusion criteria, and Doppler standardization are major strengths.

In Indian clinical settings where routine Doppler use is still underutilized, CPR offers a cost-effective and practical addition to third-trimester antenatal care in HDP cases. Incorporating CPR into routine surveillance protocols could significantly improve fetal monitoring and perinatal outcomes.[5,12,18]

Limitations of this study are:

Limited sample size

The study includes only 160 patients, which may not be sufficient to generalize findings to the wider population. A larger cohort would improve statistical power.

Single-center study

If conducted at a single hospital or medical center, the results may not be applicable to diverse populations with varying healthcare access and demographic differences.

Potential confounding factors

Other factors such as maternal comorbidities (e.g., diabetes, pre-existing hypertension), fetal growth restriction, or medication use could influence outcomes but may not have been fully accounted for.

Accuracy of Doppler measurements

Doppler assessments depend on operator expertise, and inter-observer variability could impact the reliability of cerebroplacental ratio (CPR) measurements.

CONCLUSION

Cerebroplacental ratio (CPR) is a valuable non-invasive tool in predicting adverse neonatal outcomes in hypertensive pregnancies. A CPR value <1.0 is significantly associated with increased risk of cesarean delivery, low birth weight, low Apgar scores, and NICU admission. Despite moderate sensitivity, its high specificity makes it an effective screening tool for identifying compromised fetus. Integration of CPR assessment into routine third-trimester surveillance, especially in high-risk pregnancies, is strongly recommended.

ACKNOWLEDGEMENTS

We thank the department of radiology and NICU staff for their support.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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Cite this article as: Rao N, Saxena R. Predictive value of cerebroplacental ratio measured by Doppler ultrasound for neonatal outcomes in hypertensive disorders of pregnancy: a prospective observational study. Int J Reprod Contracept Obstet Gynecol 2025;14:3060-4.